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Effects of Heat-Tunnel Temperatures on the Quality of SHRINK-FILM-WRAPPED LETTUCE

U. S. DEPARTMENT OF AGRICULTURE
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Market Quality Research Division

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EFFECTS OF HEAT-TUNNEL TEMPERATURES ON THE QUALITY OF SHRINK-FILM-WRAPPED LETTUCE

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SUMMARY

In shrink-film prepackaging tests, lettuce was injured when passed through a commercial heat tunnel at low (275°-300° F.), intermediate (310°-350° F.), or high (370°-390° F.) temperatures. Injury occurred even at exposure times which gave barely adequate heat shrinkage of the polystyrene film used to overwrap the heads of lettuce.

Much of the heat damage was minor, and was manifested within a day or two by a shriveling of the leaf edges, and by the appearance of small, dry, brown spots, usually at or near the margins of the outer leaves.

In some cases, the heat damage was more serious, and marginal zones of the outer leaves were wilted or parched and discolored. This condition, which resembled tipburn, showed up within 2 days after passage through the shrink tunnel, and was similar to damage observed on some shrink-film-wrapped heads found in New York City retail stores. Hard and more mature heads appeared to be more susceptible than others to this injury.

Overwrapped heads which were not passed through the heat tunnel did not show any of the symptoms of heat damage. The unheated lettuce had less decay and more marketable heads after 2 days at 70° F. than the heated lettuce.

BACKGROUND

Prepackaging of lettuce in heat-shrinkable films at shipping points has recently created considerable interest among lettuce shippers and marketing agencies (6, 7).[1] Removal of the wrapper leaves reduces transportation costs, especially in transcontinental shipments, where more than $200 a car can be saved (1). Retail handling costs also are lowered by prepackaging at the shipping point. Furthermore, two recent reports indicate that the shelf life of shrink-film-wrapped lettuce was found to be better than that of unwrapped lettuce (2, 3).

To date, only a small number of shippers are marketing prepackaged lettuce, almost all of it in heat-shrinkable film. Some shippers are skeptical of this practice. Others are reluctant to invest in the packaging machinery and equipment required for a large-volume operation. In addition, a number of shippers, and others in the trade, consider quality control the biggest problem in prepackaging (7).

In recent months, shrink-film-wrapped lettuce with discoloration of leaf margins, that resembled tipburn, has been observed occasionally in New York City retail stores. Federal and private produce inspectors have found similar leaf damage in a few New York deliveries of prepackaged lettuce during the past year. Wilting and discoloration of the outer leaves in shrink-film-wrapped lettuce have been reported in a survey of several terminal markets (1). The possibility of heat damage was mentioned in that report, but it was apparently discounted.

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[1] Underscored numbers in parenthesis refer to items in References, p. 8.

Because high temperatures are required to shrink the film overwrap now used commercially (8), tests were conducted to determine if heat-tunnel temperatures affected lettuce quality. The study on which this report is based was undertaken as part of the Agricultural Marketing Service's research program to maintain the quality of farm products in marketing channels.

METHODS

Four tests were conducted, one with Arizona-grown lettuce in December 1962, and three with California-grown lettuce in January 1963. The lettuce was obtained from a New York wholesaler within 1 or 2 days of arrival, after a railroad transit period of 7 days. Lettuce was prepackaged in a research laboratory in Wayne, N. J., about 30 miles from New York City.

In the December test, the lettuce was prepackaged the same day it was obtained. The wrapper leaves were removed by trimming to the cap leaves and good-quality heads were randomized into 7 lots of 12 heads each. The heads in three lots were overwrapped with a 1-mil-thick oriented polystyrene film[2] before being passed through a shrink tunnel[3] at 3 test temperatures in the range of 275° to 370° F. The passage time was 3 seconds at all temperatures. Three lots of unwrapped lettuce were similarly heated and the heads overwrapped with the plastic film after treatment. Heads in the control lot were overwrapped with the same film but were not heated.

For each of the January tests, the lettuce, 7 cartons of 24 heads each, was first held overnight at 70° F. in the Horticultural Crops Branch laboratory in New York City to warm the heads to temperatures more nearly representative of field conditions. The following morning, the lettuce was trimmed, the best heads randomized into 8 lots of 18 heads each, and the lots trucked to Wayne, N. J. There, the heads were overwrapped with polystyrene and lots were tested at 295°-300° F. (low), 345°-350° (intermediate), or 385°-390° (high) for two different exposure times. At the low and intermediate temperatures, the first exposure time was estimated to be the minimum time necessary to shrink the film adequately. The second exposure time at these temperatures was 1 second longer. An exposure time of 1.7 seconds was the shortest possible with the machine used; this period proved to be somewhat longer than the minimum necessary for an adequate shrink at the high temperature. Because of this limitation, the second exposure time at the high temperature was only 0.3 second longer than the first. Control heads were overwrapped with the same film but were not heated.

After treatment, the lettuce was taken by truck to New York, stored at 44° F. for 1 to 2 days, and then transferred to 70° for an additional 2 days. Inspections were made when the lettuce was transferred to 70°, and daily thereafter. In the final inspection of each lot, every head of lettuce was cut to determine internal damage.

RESULTS

December Test

Lettuce was injured when exposed to heat-tunnel temperatures of 275°-280°, 310°, or 370° F. The temperatures were thermostatically regulated and, in this test only, were estimated from the built-in dial thermometer on the heat chamber. In later tests, the actual tunnel temperatures were found to be 20° to 25° higher than indicated on the built-in thermometer.

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[2] Known in the trade as Kardel. Use of trade names in this report is for identification only and does not imply endorsement of the products by the Department of Agriculture.

[3] Great Lakes shrink tunnel (Model 44 C-8-15). Interior dimensions of the heat chamber were 18 x 15 1/2 x 8 1/2 inches.

Unwrapped heads, passed through the heat tunnel, showed shriveling of the outer leaves at the margin within 4 hours after treatment, and discoloration in the damaged tissues after a day. Evidence of damage usually increased during the 2 days the lettuce was held at 70° F., and considerable decay developed (table 1).

TABLE 1.--Keeping quality of head lettuce after heat-tunnel treatment for 3 seconds at various temperatures, December 1962[1]

Heat tunnel temperatures[2]	Time of inspection	Unwrapped[3]		Wrapped	
		Appearance rating [4]	Decayed heads	Appearance rating [4]	Decayed heads
Degrees F.		Average	Percent	Average	Percent
275-285[5]	After 2 days at 44° F.	2.4	0	2.8	0
	plus 1 day at 70° F.	2.1	0	2.7	12.5
	plus 2 days at 70° F.	1.3	50.0	1.8	50.0
310	After 2 days at 44° F.	1.7	0	2.8	0
	plus 1 day at 70° F.	1.3	12.5	2.7	0
	plus 2 days at 70° F.	1.2	66.7	2.0	25.0
370	After 2 days at 44° F.	1.7	0	2.8	0
	plus 1 day at 70° F.	1.3	0	2.7	0
	plus 2 days at 70° F.	1.1	75.0	1.9	33.3
Controls[6]	After 2 days at 44° F.			3.0	0
	plus 1 day at 70° F.			2.9	0
	plus 2 days at 70° F.			2.8	0

[1] Twelve heads of lettuce used in each treatment.
[2] Temperature estimated from built-in thermometer. Actual temperatures probably 20 to 25 degrees higher.
[3] Unwrapped heads were overwrapped after passage through the heat tunnel.
[4] Heads were rated individually as 3 (good), 2 (fair), 1 (poor).
[5] Some overwrapped heads had an extra 3-second exposure time.
[6] Controls consisted of wrapped heads which were not exposed to heat.

Overwrapped lettuce showed considerably less heat damage during the holding period than unwrapped heads, and much of the damage was minor. Barely noticeable small, dry, brown spots were found on the thinner and more susceptible marginal portion of surface leaves. The leaf edges were often shriveled. Some heat killing was noted on folded-over marginal tissue that appeared to be "pressed." The most serious symptom of heat damage was a wilted or parched condition of the marginal tissue on outer leaves. In a few cases, this condition extended up the leaf, and the parched tissues had turned yellow or brown.

The external appearance ratings averaged lower for heated than for unheated lettuce (table 1). By the end of the holding period, many of the heads were decayed. The decay observed was bacterial soft rot and was found only in heated heads.

The 3-second exposure time maintained throughout the test was too short for adequate film shrinkage at 275° F. The tunnel temperature was raised to 285°, and some heads with slack overwraps were passed through again. This extra exposure could account for the high decay development in these heads (table 1).

January Tests

In the three replicated tests in January, some heat injury was observed in overwrapped lettuce heads, within 48 hours of the minimal exposure to the heat in the shrink tunnel, at each temperature tested.

In most heat-affected heads, the injury was slight, but damaging heat injury was found on some heads. The most serious expression of damage was the discolored and parched condition of the marginal tissue of the surface leaves.

Throughout the holding period, the external appearance of the overwrapped but unheated heads was usually better than that of the heated overwrapped samples. No decay was observed on any heads when the lettuce was transferred from 44° F. to 70°, although moderate and severe heat damage was noted in a few heads. Decay appeared after 1 day at 70° and was more evident in the heat-treated lots than in the controls. After 2 days at 70°, the number of unheated heads showing decay was significantly lower than that of heated heads. The decay was generally more advanced in the heated lettuce, notably in those heads with extensive heat damage. Among the heated lots, the least damage occurred in heads subjected to the low (295°-300° F.) and intermediate (345°-350°) temperatures for the shorter exposure times.

There were large differences in decay development among the three tests (table 2). The least decay occurred in the first test, when lettuce of excellent quality was used. The quality of the lettuce used for the next two tests was not as good, and these lots included a larger number of overmature or hard heads. Besides their increased susceptibility to decay under normal conditions, the hard heads, when trimmed, appeared to be more adversely affected by the heat treatments than heads that were not hard.

TABLE 2.--Decay in shrink-film-wrapped lettuce after holding 2 days at 70° F. January 1963[1]

Treatment[2]		Heads per test	Decayed heads			
Heat tunnel temperatures[3]	Exposure time		Test 1	Test 2	Test 3	Average
Degrees F.	Seconds	Number	Percent	Percent	Percent	Percent
295-300	4.0	18	5.6	16.7	27.8	16.7
	5.0	18	5.6	22.2	38.9	22.2
345-350	2.0	18	5.6	11.1	22.2	13.0
	3.0	18	11.1	22.2	27.8	20.4
385-390	1.7	18	11.1	16.7	33.3	20.4
	2.0	18	11.1	22.2	27.8	20.4
Controls[4]	None	36	0	11.1	22.0	11.1[5]

[1] Prior storage at 44° F. for 1 day in test 1, and 2 days in tests 2 and 3.
[2] Pulp temperature of lettuce averaged 59°-60° F. at time of heat treatment.
[3] Specified temperatures were recorded manually inside heat tunnel.
[4] Controls consisted of wrapped heads which were not exposed to heat.
[5] Statistical significance (F - test) exists between controls and treatments.

Heat damage was the main factor affecting marketability of the lettuce upon holding for 1 to 2 days at 44° F. and after an additional day at 70° (table 3). After 2 days at 70°, decay was equally important. In a number of heads, however, the decay was too slight, at the time, to class the heads as unsalable.

TABLE 3.--Loss in marketability of prepackaged lettuce heads during holding period, January 1963

Treatment		Heads[3]	Percentage of poor heads[1]		
Heat tunnel temperature[2]	Exposure time		After 1 or 2 days at 44° F.[4]	After 1 day at 70° F.	After 2 days at 70° F.
Degrees F.	Seconds	Number	Percent	Percent	Percent
295-300	4.0	54	0	3.7	11.1
	5.0	54	0	3.7	16.7
345-350	2.0	54	0	3.7	14.8
	3.0	54	0	3.7	16.7
385-390	1.7	54	3.7	3.7	14.8
	2.0	54	1.8	3.7	13.0
Controls[5]	None	108	0	0	7.4

[1] Unsalable or of questionable salability without trimming.
[2] Specified temperatures were recorded manually inside heat tunnel.
[3] Combined January tests.
[4] After 1 day in test 1, and 2 days in tests 2 and 3.
[5] Controls consisted of wrapped heads which were not exposed to heat.

The temperatures in these tests (table 2) were determined by inserting a calibrated long-stem metal thermometer into the heat tunnel. The test temperatures were actually 20° to 25° F. higher than readings on the built-in heat tunnel thermometer, indicating the need to check on temperature controls in lettuce prepackaging.

DISCUSSION

Heat injury in prepackaged lettuce depends upon both exposure time and the temperature in the shrink tunnel. The temperatures utilized in these tests were believed to be representative of the usual range in most commercial operations. A shrink temperature of 375° F. and a 2-second exposure time were noted in a commercial lettuce prepackaging operation in the East.

Heat damage produced in these tests was similar to a condition reported on shrink-film-packaged lettuce in several terminal markets (1), and resembled leaf damage observed in some shrink-film-wrapped heads in New York retail stores. The heat-parched, discolored leaf could be mistaken for the effects of tipburn, a physiological disorder of field origin. However, heat damage affects only one or two outer leaves, while tipburn usually extends deeper into the heads. Some tipburn was present in December test lettuce, but it was almost completely absent in the other tests.

After the completion of the tests, the writers learned that western lettuce growers have been shipping lettuce in a modified shrink pack, reportedly produced at shrink tunnel temperatures of 250° F. and lower. Shrinkage at such low temperatures could have been accomplished by using extremely high-velocity air in the tunnel or longer exposure times. However, shrink-film-wrapped western lettuce retailed in New York stores during the late summer of 1963 still showed inconsistent quality with minor heat injury on the outer leaves and occasional occurrences of more serious heat damage.

The chief advantage of prepackaging lettuce at the shipping point is the saving in transportation costs, which can also be realized by conventional packing of field-trimmed heads (4). The application of heat at the temperatures used in this study damaged the market quality of the lettuce by injuring leaf tissue and predisposing it to decay. Prepackaging lettuce in plastic film bags without heat-shrinking eliminates the heat hazard and prolongs the storage life (5).

The use of thinner films requiring shorter exposure times, or new films that shrink at lower temperatures, may reduce heat damage. Under the conditions of these tests, however, the market quality of prepackaged lettuce was maintained better when the polystyrene film was not heat-shrunk.

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